PATENT ABSTRACTS OF JAPAN

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(54) COATED HARD TOOL

(57)Abstract:

PROBLEM TO BE SOLVED: To improve the adhesion of a hard coating film by specifying the ratio of the diffraction intensity between the (200) plane and the (111) plane in the X-ray diffraction of compd. coating of TiAl and third component, composing the third components of Si or the like are interposing a metallic alloy layer composed of Ti, TiAl or TiAl and third components with a specified thickness on the space between a substrate and the coating film.

SOLUTION: In the case, as the third components, one or more kinds among Si, Zr, Hf, Y, Nb, Nd and Cr are added, the oxidation-resistance of the coating film is improved. When the diffraction intensities of the (200) plane and the (111) plane are respectively defined as I (200) and I (111), the ratio of I (200)/I (111) is regulated to ≤2. In the case of >2, it can not show sufficient wear resistance in the cutting of a high hardness material in which the temp. of the cutting edge is made high. The thickness of the metallic layer to be interposed on the space between the substrate and the coating is regulated to 2 to 1000 nm. In the case of the lower limit or below, it has no effect on the improvement of the adhesion of the coating film, and in the case of above the upper limit, slippage is generated in the metallic layer, and the coating film is made easy to peel.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] The invention in this application relates to the covering hard metal which has the abrasion resistance which was excellent in the adhesion of a coat, consequently was excellent.
[0002]
[Description of the Prior Art] Conventionally, although it was general, Ti is made to contain aluminum, the research which raises abrasion resistance and oxidation resistance is made, and various coats', such as TiN's and TiCN's, being general-purpose and examples which accept the addition effectiveness of aluminum also exist in JP,8-267306,A in recent years. However, when these examples added aluminum to a coat, the improvement of the coat itself, such as the oxidation resistance of a coat and abrasion resistance, was made. Moreover, although using a TiN coat for a substrate is also proposed as an approach of improving the adhesion of a TiAlN coat so that this number official report may see, the present condition is having come to acquire sufficient adhesion.
[0003]
[Problem(s) to be Solved by the Invention] Recently, the inclination which high-streamlines cutting is strong and cutting speed and cutting delivery tend to increase. In such a case, as a factor which governs a tool life, the adhesion of a coat will become very important from the abrasion resistance of a coat, and oxidation resistance. generally residual compression stress is high, as a result, the adhesion of a coat is not satisfied enough and the coat which added said aluminum is such -- high -- in efficiency cutting, a result which a coat often exfoliates and spoils the life of a tool and dependability is brought. Furthermore, although it is necessary to make the oxidation resistance of a coat improve further in high speed cutting, still sufficient effectiveness is not accepted. Therefore, also in such high efficiency cutting, it is long lasting, and in order to realize stable cutting, it is necessary to raise the adhesion of a coat further. On the other hand, although the research which reduces the residual compression stress of the coat which is the cause of fundamental of degrading adhesion itself is also made in order to raise adhesion, the present condition is having come to see still sufficient effectiveness.
[0004]
[Means for Solving the Problem] By making the coat of a soft metal intervene under the hard anodic oxidation coatings which have the high compressive stress containing aluminum as a result of repeating research wholeheartedly that this invention persons should improve the adhesion of a coat, absorption relaxation is carried out and the compressive stress with the high hard anodic oxidation coatings containing aluminum came to acquire the knowledge which can improve the adhesion of result hard anodic oxidation coatings remarkably. It is effective to add the third component to oxidation-resistant improvement.
[0005] When high compressive stress exists in a coat, it is the factor in which the high shearing stress resulting from this compressive stress acts on the interface of a coat and a base hard metal, and this shearing stress spoils the adhesion of a coat, and suggests resulting in easing or removing this raising the adhesion of a coat. That is, it is thought by making a comparatively soft layer intervene between the coat

which has high compressive stress, and a base hard metal that this comparatively soft coat absorbed the shearing stress which originates in high compressive stress and is generated in an interface, and eased. Moreover, as mentioned above, there is also an example between which the nitride of Ti etc. is made to be placed, but according to research of this invention persons, when the metal layer of Ti is used, it is more effective to relaxation of stress. A metal layer is considered that absorbed energy demonstrates an effectiveness target more to the stress relaxation of a coat that it is easy to move a rearrangement since Young's modulus is low high again. Having demonstrated the effectiveness in which the direction which, on the other hand, used the nitride of Ti which made aluminum contain etc. was more excellent to improvement in adhesion was admitted. If few oxidizing zones surely formed exist when this is put on the front face of a base hard metal into air, although the adhesion of a coat deteriorates remarkably, when aluminum recognizes little existence into the coat formed as a substrate, the result which the thermite reaction which returns this oxidizing zone occurs, removes an oxidizing zone, and improves the adhesion of a coat remarkably at the time of coating initiation will be brought about. This is a ****** thing at the principle which the oxygen of the oxidizing zone on the front face of a base and the ion of aluminum react, and the oxide of aluminum forms an oxide in a coat since the free energy of formation is very easy to be formed low, and removes the oxidizing zone on the front face of a base.
[0006] The residual compression stress of the coat itself depends on coating conditions strongly. Generally, in coating under the conditions that the energy of ion is low, the residual compression stress of a coat brings a low result, and the residual compression stress of a coat becomes high in coating under the conditions that the energy of ion is high, on the contrary. The bias voltage and the degree of vacuum which are mainly given to a base determine the energy of ion. According to research of this invention persons, when residual stress of a coat is high, the hardness of a coat tends to carry out orientation of the coat to (111) in an X diffraction again highly. In recent years, it must be in the inclination to be used when a cemented carbide end mill cuts high degree-of-hardness material at high speed, and since the edge of a blade becomes an elevated temperature in such cutting, much more abrasion resistance must be required and the degree of hardness of a coat must be high. Moreover, since oxidation occurs, under such cutting conditions, the oxidation resistance of a coat is required further.
[0007] As a result of this invention person's trying addition of the various third components to an oxidation-resistant improvement, in Si, Hf, Y, Zr, Cr, Nb, and Nd, it became clear to segregate to the grain boundary of the coat of TiAlN and to control diffusion of the oxygen in a grain boundary, and these third components brought a result whose oxidation resistance of a coat improves remarkably.
[0008] Next, the reason which limited the numeric value is explained. In the hard layer, when the content of aluminum turned around 5% the bottom, the addition effectiveness of aluminum was not accepted, oxidation resistance did not improve in the wear-resistant list of a coat, but since it would result in ****** hardness falling to the property as AlN, and spoiling the abrasion resistance of a coat if it is made to contain exceeding 75%, the Ti/aluminum ratio was set to 95/5 to 25/75. Residual compression stress of the coat was low, and since a degree of hardness was not able to demonstrate sufficient abrasion resistance in cutting of the high degree-of-hardness material from which the circumference of the bottom and the edge of a blade become an elevated temperature about 3000 with Vickers hardness, the ratio of I (200)/I (111) made the case of two or more two or less. Moreover, since the thickness of this metal layer made to intervene did not have effectiveness in an improvement of the adhesion of stress relaxation, i.e., a coat, as it is 2nm or less, and it would bring a result in which a skid occurs and a coat exfoliates easily within a metal layer if 1000nm is exceeded, it was set to 2 to 1000nm.

[0009]
[Example] Hereafter, this invention is explained based on an example. In the conditions shown in Table 1 using a small arc ion plating system, coating of the example of this invention manufactured the examples 1-8 of this invention of 3 yuan using the metal target (in addition to Ti and aluminum, the metallic element used the target which added and manufactured the element of Si, Hf, Y, Nb, Nd, and Zr.) of a system using the end mill made from cemented carbide. The examples 9-12 of a comparison performed coating using the target of Ti or TiAl, and manufactured the end mill made from a covered

cemented carbide. Moreover, in coating of an alloy metal layer, installation of nitrogen gas was stopped and was performed.

[0010]

[Table 1]

試料番号		コーティング条件 バイアス電圧(V)	真空度 mbar	皮膜 第1層 金属層	皮膜 第2層 硬質層	I(200) / I(111)	折損時の切削長 (m)
本発明例	1	300	4×10^{-2}	Ti 3nm	$Ti_{0.5}Al_{0.4}Si_{0.1}N$	0.6	25.6
	2	↑	↑	Ti 100nm	$Ti_{0.5}Al_{0.4}Hf_{0.1}N$	0.4	31.4
	3	↑	↑	Ti 850nm	$Ti_{0.5}Al_{0.4}Y_{0.1}N$	0.8	27.8
	4	↑	↑	$Ti_{0.5}Al_{0.4}Nb_{0.1}$ 100nm	$Ti_{0.5}Al_{0.4}Nb_{0.1}N$	0.6	29.8
	5	↑	↑	$Ti_{0.5}Al_{0.4}Nd_{0.1}$ 100nm	$Ti_{0.8}Al_{0.1}Nd_{0.1}N$ $Ti_{0.5}Al_{0.4}Nd_{0.1}N$ の交互15層	1.5 0.3	24.5
	6	↑	↑	$Ti_{0.7}Al_{0.2}Zr_{0.1}$ 100nm	$Ti_{0.7}Al_{0.2}Zr_{0.1}N$ $Ti_{0.5}Al_{0.4}Zr_{0.1}N$ の交互30層	1.5 12.9	24.5
	7	↑	↑	$Ti_{0.7}Al_{0.1}Nb_{0.2}$ 500nm	$Ti_{0.7}Al_{0.1}Nb_{0.2}N$	0.9	21.8
	8	↑	↑	$Ti_{0.4}Al_{0.4}Nb_{0.2}N$ 100nm	$Ti_{0.4}Al_{0.4}Nb_{0.2}N$	0.6	27.9
比較例	9	100	↑	free	$Ti_{0.5}Al_{0.5}N$	5.6	8.8
	10	↑	↑	free	$Ti_{0.5}Al_{0.5}N$	7.4	4.5
	11	↑	↑	TiN 0.1u	↑	5.7	6.8
	12	↑	↑	TiN 1.0μ	$Ti_{0.5}Al_{0.5}N$	6.8	10.3

[0011] It cut until it performed the cutting test and broke in the following cutting conditions with the

obtained end mill. The length of cut at the time of breakage occurring was written together to Table 1.
End mill phi8mm Six-sheet ****** material SKD11 HRC 60 cutting speed 20 m/min delivery 0.06mm / cutting-edge slitting 12mm x 0.8mm cutting method Dry type cutting (Dry)
[0012] In the examples 1-8 of this invention, since cutting of quantity degree-of-hardness material also had little exfoliation of a coat, and that of long distance cutting was possible, since the metal layer or the alloy metal layer is made to intervene and the coat has stuck well, and orientation of the coat was carried out to (200), abrasion resistance also came out enough and stable cutting has been realized, so that more clearly than Table 1. Moreover, since oxidation resistance was raised and it closed by adding the third element, abrasion resistance can be raised more.
[0013] Next, coating of the examples 13-20 of this invention and the examples 21-24 of a comparison was performed to the end mill made from cemented carbide on the KOTEYUNGU conditions shown in Table 2, it cut in the following cutting items, and the abrasion loss after 50m cutting was calculated. The thickness of a coat was unified into 2.0 micrometers in this example.
End mill Two-sheet cutting edge **-ed [phi10mm] material S50C HRC12 cutting speed 100 m/min delivery 0.1mm / cutting-edge slitting 10mmx1mm cutting method Abrasion loss is written together to the dry type (Dry) cutting table 2.
[0014]
[Table 2]

試料番号		コーティング条件		皮膜			摩耗量 (mm)
		バイアス電圧(V)	真空度 mbar	金属層	I(200)/I(111)	硬質層	
本発明例	1	300	4×10^{-2}	Ti 3nm	0.55	$Ti_{0.5}Al_{0.4}Si_{0.1}N$	0.151
	2	↑	↑	Ti 100nm	0.67	$Ti_{0.5}Al_{0.4}Hf_{0.1}N$	0.145
	3	↑	↑	Ti750nm	0.98	$Ti_{0.5}Al_{0.4}Nb_{0.1}N$	0.143
	4	↑	↑	$Ti_{0.9}Al_{0.1}$ 100nm	0.37	$Ti_{0.5}Al_{0.4}Nd_{0.1}N$	0.164
	5	↑	↑	$Ti_{0.8}Al_{0.1}Cr_{0.1}$ 50nm	0.45 0.67	$Ti_{0.8}Al_{0.1}Cr_{0.1}N$ $Ti_{0.5}Al_{0.4}Cr_{0.1}N$ の交互 30 層	0.167
	6	↑	↑	$Ti_{0.8}Al_{0.1}Y_{0.1}$ 100nm	1.67 0.56	$Ti_{0.8}Al_{0.1}Y_{0.1}N$ $Ti_{0.5}Al_{0.4}Y_{0.1}N$ の交互 50 層	0.163
	7	↑	↑	$Ti_{0.5}Al_{0.5}$ 100nm	0.77	$Ti_{0.5}Al_{0.4}Si_{0.1}N$	0.135
	8	↑	↑	$Ti_{0.5}Al_{0.5}$	0.48	$Ti_{0.3}Al_{0.6}Si_{0.1}N$	0.166
比較例	9	100	↑	Free	5.47	$Ti_{0.5}Al_{0.5}N$	0.356
	10	↑	↑	Free	8.56	$Ti_{0.7}Al_{0.3}N$ $Ti_{0.5}Al_{0.5}N$ の交互 15 層	0.379
	11	↑	↑	TiN 0.1μ	8.22	$Ti_{0.5}Al_{0.5}N$	0.406
	12	↑	↑	TiN 1.0μ	6.78	↑	0.422

[0015] In the example of this invention in which a metal layer or an alloy metal layer is made to intervene, and the coat is carrying out orientation to (200), a covering end mill has the good adhesion of a coat, and realizes cutting in which high-speed quantity delivery was also stabilized extremely so that more clearly than Table 2. Moreover, in high-speed quantity delivery, it is in the inclination for edge-of-a-blade temperature to become high, oxidation-resistant effectiveness was demonstrated, and the long lasting coat was obtained.
[0016] Furthermore, coating which shows to the drill made from cemented carbide (cutting diameter phi6mm) at the examples 25-29 of this invention, and is shown in the examples 31-32 of a comparison at a list on the coating conditions shown in Table 3 was performed, and it examined by the cutting item

shown below.
**-ed material SCM440 cutting speed 70 m/min delivery 0.1 mm/rev hole depth 15mm cutting method Wet (Wet)
Also in this example, the thickness of a coat could be 3.0micro.
The abrasion loss of the edge of a blade after 3000 hole processing is written together to Table 3.
[0017]
[Table 3]

試料番号		コーティング層			摩耗量
		金属層	硬質層	I(200)/I(111)	(mm)
本発明例	1	$Ti_{0.9}Al_{0.1}$ 5nm	$Ti_{0.5}Al_{0.4}Y_{0.1}N$	0.67	0.211
	2	$Ti_{0.9}Al_{0.1}$ 50nm	$Ti_{0.5}Al_{0.4}Si_{0.1}N$	0.55	0.198
	3	$Ti_{0.9}Al_{0.1}$ 800nm	$Ti_{0.5}Al_{0.4}Nb_{0.1}N$	0.47	0.199
	4	$Ti_{0.8}Al_{0.1}Nd_{0.1}$ 400nm	$Ti_{0.8}Al_{0.1}Nd_{0.1}N$ $Ti_{0.5}Al_{0.4}Nd_{0.1}N$ の交互 15 層	0.39 0.49	0.231
	5	Ti 50nm	$Ti_{0.4}Al_{0.4}Nb_{0.2}N$	0.55	0.222
比較例	6	Free	$Ti_{0.5}Al_{0.5}N$	7.87	2733 穴折損
	7	Free	$Ti_{0.5}Al_{0.5}N$	5.99	0.456
	8	TiN 1.0u	$Ti_{0.5}Al_{0.5}N$	8.57	0.501

[0018] While making the metal layer or the alloy metal layer intervene, sticking by the tool which includes continuous cutting like a drill and having abrasion resistance, what added the element which is excellent in oxidation resistance was more effective so that more clearly than Table 3.
[0019] Next, since [synergistic-effect-like / oxidation resistance] it was not able to express, the coat which includes the addition effectiveness of the various third components for the third component was coated like the previous example, and it was made to oxidize in 900 degrees C and atmospheric air in cutting for 1 hour. The oxidation layer thickness then formed was measured by cross-section observation. The result is shown in Table 4.
[0020]
[Table 4]

	皮　膜	酸化層厚さ（ミクロン）
本発明例	$Ti_{0.5}Al_{0.4}Si_{0.1}N$	1.2
	$Ti_{0.3}Al_{0.4}Si_{0.3}N$	0.7
	$Ti_{0.5}Al_{0.4}Zr_{0.1}N$	1.5
	$Ti_{0.3}Al_{0.4}Zr_{0.3}N$	1.0
	$Ti_{0.5}Al_{0.4}Hf_{0.1}N$	1.3
	$Ti_{0.5}Al_{0.4}Y_{0.1}N$	0.9
	$Ti_{0.3}Al_{0.4}Y_{0.3}N$	0.6
	$Ti_{0.5}Al_{0.45}Nb_{0.05}N$	1.5
	$Ti_{0.5}Al_{0.4}Nb_{0.1}N$	1.0
	$Ti_{0.3}Al_{0.4}Nd_{0.3}N$	0.7
比較例	$Ti_{0.5}Al_{0.5}N$	3.2
	$Ti_{0.4}Al_{0.6}N$	2.7
	Ti N	5
	Ti CN	5

[0021] Oxidation resistance was expressed with the thickness which oxidizes from a front face as the standard. If oxidation advances to the interior of membranous, cubical expansion arises by oxidation, and the film separates or will be away held by cutting. Therefore, if oxidation is stopped only near the front face, although a front face serves as an oxide, since the film with the precise interior is maintained, it has function sufficient as a tool. Especially, the effectiveness was remarkable at Y, Si, and Nb.

[0022]

[Effect of the Invention] By reducing the stress which prepares a metal or an alloy metal layer between base-coats, and remains the adhesion of a coat to a coat, as explanation was given [above-mentioned] It can act and bite with milling cutter cutting, an end mill, a drill, etc., and sufficient adhesion also for the impact at the time can be maintained. By being able to demonstrate the abrasion resistance of coat original, and the coat's controlling an I(200)/I (111) ratio for a stacking tendency or less to two, and adding the third component to it While demonstrating the abrasion resistance which bore and rubbed against the impact and was excellent in wear, it was able to consider as the coat excellent in oxidation resistance.

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CLAIMS

[Claim(s)]
[Claim 1] In the covering hard tool which covered to the multilayer the monolayer of the nitride with which the rate of an atomic ratio of Ti/aluminum consists of Ti, aluminum, and the third component of 95/5 to 25/75, carbon nitride, a charcoal nitric oxide, ********, and **** boride, or two sorts or more The diffraction reinforcement of the field in the X diffraction (200) of this TiAl and the compound coat of the third component I (200), When diffraction reinforcement of a field is set to I (111), the ratio of I (200)/I (111) is two or less. (111) The third component is one sort of Si, Zr, Hf, Y, Nb, Nd, and Cr, or two sorts or more. And the covering hard tool characterized by making the metal alloy layer which consists of a base, this TiAl, Ti and TiAl that have the thickness of 2 to 1000nm between the compound coats of the third component or TiAl, and the third component intervene.
[Claim 2] The covering hard tool characterized by bases being an end mill made from cemented carbide, and a drill in a covering hard tool according to claim 1.

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最終頁に続く

(54)【発明の名称】　被覆硬質工具

(57)【要約】

【課題】　Ti、Al及び第三成分からなる化合物を被覆した工具において、皮膜の密着性を改善し、かつ、耐酸化性の向上を計った工具を提供することを目的とする。

【解決手段】　Ti、Al及び第三成分からなる化合物を被覆した工具において、該TiAl及び第三成分の化合物皮膜のX線回折における（200）面の回折強度をI（200）、（111）面の回折強度をI（111）とした場合にI（200）／I（111）の比が2以下であり、第三成分はSi、Zr、Hf、Y、Nb、Nd、Crの1種もしくは2種以上であり、かつ基体と該TiAlと第三成分の化合物皮膜の間に2nmから1000nmの厚さを有するTi、TiAl若しくはTiAlと第三成分よりなる金属合金層を介在させる。

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【特許請求の範囲】

【請求項１】　Ｔｉ／Ａｌの原子比率が９５／５から２５／７５のＴｉとＡｌ及び第三成分からなる窒化物、炭窒化物、炭窒酸化物、窒硼化物、炭窒硼化物の単層もしくは二種以上を多層に被覆した被覆硬質工具において、該ＴｉＡｌ及び第三成分の化合物皮膜のＸ線回折における（２００）面の回折強度をＩ（２００）、（１１１）面の回折強度をＩ（１１１）とした場合にＩ（２００）／Ｉ（１１１）の比が2以下であり、第三成分はＳｉ、Ｚｒ、Ｈｆ、Ｙ、Ｎｂ、Ｎｄ、Ｃｒの１種もしくは2種以上であり、かつ基体と該ＴｉＡｌと第三成分の化合物皮膜の間に２ｎｍから１０００ｎｍの厚さを有するＴｉ、ＴｉＡｌ若しくはＴｉＡｌと第三成分よりなる金属合金層を介在させたことを特徴とする被覆硬質工具。

【請求項２】　請求項１記載の被覆硬質工具において、基体が超硬合金製エンドミル、ドリルであることを特徴とする被覆硬質工具。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本願発明は、皮膜の密着性に優れ、その結果、優れた耐摩耗性を有する被覆硬質合金に関する。

【０００２】

【従来の技術】従来、ＴｉＮ、ＴｉＣＮ等の皮膜が汎用的、かつ、一般的であったが、近年、ＴｉにＡｌを含有させ、耐摩耗性・耐酸化性を向上させる研究がなされ、特開平８－２６７３０６号公報には、Ａｌの添加効果を認める事例も種々存在する。しかしながら、これらの事例は皮膜にＡｌを添加することにより、皮膜の耐酸化性、耐摩耗性といった皮膜そのものの改善が行われたにすぎない。また、ＴｉＡｌＮ皮膜の密着性を改善する方法として、同号公報にみられるように、ＴｉＮ皮膜を下地に用いることも提案されているが、十分な密着性を得るには至っていないのが現状である。

【０００３】

【発明が解決しようとする課題】最近では、切削を高能率化する傾向が強く、切削速度ならびに切削送りは増加する傾向にある。このような場合工具寿命を支配する因子としては、皮膜の耐摩耗性、耐酸化性よりも皮膜の密着性が極めて重要なものとなる。前記Ａｌを添加した皮膜は一般に残留圧縮応力が高く、その結果皮膜の密着性が十分満足されるものでなく、この様な高能率な切削加工においては、しばしば皮膜が剥離し工具の寿命、信頼性を損なう結果となっている。さらに、高速切削においてはさらに皮膜の耐酸化性を向上せしめる必要があるがいまだ十分な効果は認められていない。従って、この様な高能率切削においても、長寿命でかつ安定した切削を実現するためには、皮膜の密着性をさらに高める必要がある。一方、密着性を向上させるために、密着性を劣化させる根本原因である皮膜の残留圧縮応力そのものを低減させる研究もなされてはいるが、いまだ十分な効果をみるに至っていないのが現状である。

2

【０００４】

【課題を解決するための手段】本発明者らは皮膜の密着性を改善すべく鋭意研究を重ねた結果、Ａｌを含有する高い圧縮応力を有する硬質皮膜の下に軟らかい金属の皮膜を介在させることにより、Ａｌを含有する硬質皮膜の高い圧縮応力は吸収緩和され、結果硬質皮膜の密着性を著しく改善できる知見を得るに至った。耐酸化性の向上に対しては第三成分を添加することが有効である。

【０００５】皮膜に高い圧縮応力が存在する場合には、皮膜と基体硬質合金の界面にこの圧縮応力に起因する高い剪断応力が作用し、この剪断応力が皮膜の密着性を損なう要因であり、これを緩和、もしくは除去することが皮膜の密着性を向上させる結果となることを示唆するものである。つまり、高い圧縮応力を有する皮膜と基体硬質合金の間に比較的軟らかい層を介在させることにより、この比較的軟らかい皮膜が高い圧縮応力に起因して界面に発生する剪断応力を吸収、緩和したものと考えられる。また、前述したように、Ｔｉの窒化物等を介在させる事例もあるが、本発明者らの研究によれば、Ｔｉの金属層を用いた場合、より応力の緩和に対して効果的である。金属層は吸収エネルギーが高くまたヤング率が低いため転位が移動し易く皮膜の応力緩和に対しより効果的を発揮するものと考えられる。一方、Ａｌを含有させたＴｉの窒化物等を用いた方が密着性の向上に対してはより優れた効果を発揮することが認められた。これは、基体硬質合金の表面に空気中に置いておいたときに必ず形成される僅かな酸化層が存在すると皮膜の密着性は著しく劣化するが、下地として形成される皮膜中にＡｌが少量存在することによりコーティング開始時に、この酸化層を還元するテルミット反応が起き酸化層を除去し皮膜の密着性を著しく改善する結果をもたらす。これはＡｌの酸化物は生成自由エネルギーが低く極めて形成されやすいため基体表面の酸化層の酸素とＡｌのイオンが反応して皮膜内に酸化物を形成し、基体表面の酸化層を除去する原理に基ずくものである。

【０００６】皮膜そのものの残留圧縮応力はコーティング条件に強く依存する。一般にイオンのエネルギーが低い条件下のコーティングにおいては、皮膜の残留圧縮応力は低い結果となり、反対にイオンのエネルギーが高い条件下のコーティングにおいては、皮膜の残留圧縮応力は高くなる。イオンのエネルギーを決定するのは主に基体に付与するバイアス電圧と真空度である。本発明者らの研究によれば皮膜は残留応力が高い場合には皮膜の硬さが高くまたＸ線回折において皮膜は（１１１）に配向する傾向にある。近年、超硬合金エンドミルは高硬度材を高速で切削する場合に用いられる傾向にあり、このような切削においては、刃先が高温になるため、より一層の耐摩耗性が要求され、皮膜の硬度は高くなければなら

ない。また酸化が発生するため、このような切削条件下では、より一層皮膜の耐酸化性が要求される。

【0007】耐酸化性の改善に対し本発明者は種々の第三成分の添加を試みた結果Ｓｉ、Ｈｆ、Ｙ、Ｚｒ、Ｃｒ、Ｎｂ、ＮｄにおいてこれらW第三成分はＴｉＡｌＮの皮膜の結晶粒界に偏析し粒界での酸素の拡散を抑制することが明らかになり、皮膜の耐酸化性が著しく向上する結果となった。

【0008】次に数値を限定した理由を述べる。硬質層においては、Ａｌの含有率は5％を下まわると、Ａｌの添加効果が認められず皮膜の耐摩耗性並びに耐酸化性は向上せず、７５％を越えて含有させるとＡｌＮとしての特性に近ずき硬さが低下し皮膜の耐摩耗性を損なう結果となるため、Ｔｉ／Ａｌ比は９５／5から２５／７５とした。Ｉ（２００）／Ｉ（１１１）の比は2以上の場合は皮膜は残留圧縮応力が低く、硬度がビッカース硬度で３０００を下まわり、刃先が高温になる高硬度材の切削においては、十分な耐摩耗性を発揮できないため、2以下とした。また、この介在させる金属層の厚さは２ｎｍ以下であると応力緩和つまり皮膜の密着性の改善に効果がなく、１０００ｎｍを越えると金属層内ですべりが発生し皮膜が容易に剥離する結果となるため、２ｎｍから１０００ｎｍとした。

【0009】

【実施例】以下、実施例に基づいて本発明を説明する。超硬合金製のエンドミルを用いて、小型アークイオンプレーティング装置を用い表１に示す条件において、本発明例のコーティングは3元系の金属ターゲット（金属元素はＴｉ、Ａｌに加え、Ｓｉ、Ｈｆ、Ｙ、Ｎｂ、Ｎｄ、Ｚｒの元素を添加して製作したターゲットを用いた。）を使用して本発明例1～8を製作した。比較例9～１２はＴｉ又はＴｉＡｌのターゲットを用いてコーティングを行い被覆超硬合金製のエンドミルを製作した。また、合金金属層のコーティングにおいては、窒素ガスの導入を止めて行った。

【0010】

【表1】

試料番号		コーティング条件 バイアス電圧(V)	真空度 mbar	皮膜 第1層 金属層	皮膜 第2層 硬質層	I(200)/I(111)	折損時の切削長 (m)
本発明例	1	300	4 x 10^{-2}	Ti 3nm	$Ti_{0.5}Al_{0.4}Si_{0.1}N$	0.6	25.6
	2	↑	↑	Ti 100nm	$Ti_{0.5}Al_{0.4}Hf_{0.1}N$	0.4	31.4
	3	↑	↑	Ti 850nm	$Ti_{0.5}Al_{0.4}Y_{0.1}N$	0.8	27.8
	4	↑	↑	$Ti_{0.5}Al_{0.4}Nb_{0.1}$ 100nm	$Ti_{0.5}Al_{0.4}Nb_{0.1}N$	0.6	29.8
	5	↑	↑	$Ti_{0.5}Al_{0.4}Nd_{0.1}$ 100nm	$Ti_{0.8}Al_{0.1}Nd_{0.1}N$ $Ti_{0.5}Al_{0.4}Nd_{0.1}N$ の交互15層	1.5 0.3	24.5
	6	↑	↑	$Ti_{0.7}Al_{0.2}Zr_{0.1}$ 100nm	$Ti_{0.7}Al_{0.2}Zr_{0.1}N$ $Ti_{0.5}Al_{0.4}Zr_{0.1}N$ の交互30層	1.5 12.9	24.5
	7	↑	↑	$Ti_{0.7}Al_{0.1}Nb_{0.2}$ 500nm	$Ti_{0.7}Al_{0.1}Nb_{0.2}N$	0.9	21.8
	8	↑	↑	$Ti_{0.4}Al_{0.4}Nb_{0.2}N$ 100nm	$Ti_{0.4}Al_{0.4}Nb_{0.2}N$	0.6	27.9
比較例	9	100	↑	free	$Ti_{0.5}Al_{0.5}N$	5.6	8.8
	10	↑	↑	free	$Ti_{0.5}Al_{0.5}N$	7.4	4.5
	11	↑	↑	TiN 0.1u	↑	5.7	6.8
	12	↑	↑	TiN 1.0μ	$Ti_{0.5}Al_{0.5}N$	6.8	10.3

【0011】得られたエンドミルで次の切削条件にて切削テストを行い、折損するまで切削を行った。折損が発生した時点の切削長を表1に併記した。

エンドミル　φ8mm　6枚刃
被削材　　　SKD11　HRC　60
切削速度　　20m／min
送り　　　　0．06mm／刃
切り込み　　12mm　x　0．8mm
切削方式　　乾式切削（Dry）

＊【0012】表1より明らかなように、本発明例1～8では、金属層又は合金金属層を介在させているため皮膜が良く密着しているため高硬度材の切削でも皮膜の剥離が少なく、長い距離切削ができ、また皮膜を（200）に配向させているため耐摩耗性も十分で安定な切削が実現出来た。また第三元素を添加することにより耐酸化性を向上させしめたのでより耐摩耗性を向上させることが出来たものである。

＊【0013】次に、表2に示すコーテュング条件で超硬

合金製エンドミルに本発明例１３～２０と比較例２１～２４のコーティングを行い、以下の切削諸元にて切削を行い５０ｍ切削後の摩耗量を求めた。本実施例では皮膜の厚さを２．０μｍに統一した。
エンドミル　２枚刃　Φ１０ｍｍ
被削材　　Ｓ５０Ｃ　ＨＲＣ１２
切削速度　１００ｍ／ｍｉｎ
送り　　　０．１ｍｍ／刃
切り込み　１０ｍｍｘ１ｍｍ
切削方式　乾式（Ｄｒｙ）切削
表２に摩耗量を併記する。
【００１４】
【表２】

試料番号		コーティング条件 バイアス電圧(V)	真空度 mbar	皮膜 金属層	I(200)/I(111)	硬質層	摩耗量 (mm)
本発明例	1	300	4×10^{-3}	Ti 3nm	0.55	$Ti_{0.5}Al_{0.4}Si_{0.1}N$	0.151
	2	↑	↑	Ti 100nm	0.67	$Ti_{0.5}Al_{0.4}Hf_{0.1}N$	0.145
	3	↑	↑	Ti750nm	0.98	$Ti_{0.5}Al_{0.4}Nb_{0.1}N$	0.143
	4	↑	↑	$Ti_{0.9}Al_{0.1}$ 100nm	0.37	$Ti_{0.5}Al_{0.4}Nd_{0.1}N$	0.164
	5	↑	↑	$Ti_{0.8}Al_{0.1}Cr_{0.1}$ 50nm	0.45 0.67	$Ti_{0.8}Al_{0.1}Cr_{0.1}N$ $Ti_{0.5}Al_{0.4}Cr_{0.1}N$ の交互30層	0.167
	6	↑	↑	$Ti_{0.8}Al_{0.1}Y_{0.1}$ 100nm	1.67 0.56	$Ti_{0.8}Al_{0.1}Y_{0.1}N$ $Ti_{0.5}Al_{0.4}Y_{0.1}N$ の交互50層	0.163
	7	↑	↑	$Ti_{0.5}Al_{0.5}$ 100nm	0.77	$Ti_{0.5}Al_{0.4}Si_{0.1}N$	0.135
	8	↑	↑	$Ti_{0.5}Al_{0.5}$	0.48	$Ti_{0.3}Al_{0.6}Si_{0.1}N$	0.166
比較例	9	100	↑	Free	5.47	$Ti_{0.5}Al_{0.5}N$	0.356
	10	↑	↑	Free	8.56	$Ti_{0.7}Al_{0.3}N$ $Ti_{0.5}Al_{0.5}N$ の交互15層	0.379
	11	↑	↑	TiN 0.1μ	8.22	$Ti_{0.5}Al_{0.5}N$	0.406
	12	↑	↑	TiN 1.0μ	6.78	↑	0.422

【００１５】表２より明らかなように、金属層又は合金金属層を介在させ、かつ、皮膜が（２００）に配向している本発明例では、被覆エンドミルは皮膜の密着性が良好で高速高送りでも極めて安定した切削を実現するものである。また、高速高送りでは刃先温度が高くなる傾向にあり、耐酸化性の効果が発揮され、長寿命な皮膜が得られた。
【００１６】更に、表３に示すコーティング条件にて超硬合金製ドリル（刃径Φ６ｍｍ）に本発明例２５～２９、並びに比較例３１～３２に示すコーティングを行

い、以下に示した切削諸元により試験を行った。

被削材　ＳＣＭ４４０

切削速度　７０ｍ／ｍｉｎ

送り　０．１ｍｍ／ｒｅｖ

穴深さ　１５ｍｍ　＊

＊切削方式　湿式（Ｗｅｔ）

本実施例においても、皮膜の膜厚は３．０μとした。表３に３０００穴加工後の刃先の摩耗量を併記する。

【００１７】

【表３】

試料番号		コーティング層			摩耗量
		金属層	硬質層	I(200)/I(111)	（mm）
本発明例	1	$Ti_{0.9}Al_{0.1}$ 5nm	$Ti_{0.5}Al_{0.4}Y_{0.1}N$	0.67	0.211
	2	$Ti_{0.9}Al_{0.1}$ 50nm	$Ti_{0.5}Al_{0.4}Si_{0.1}N$	0.55	0.198
	3	$Ti_{0.9}Al_{0.1}$ 800nm	$Ti_{0.5}Al_{0.4}Nb_{0.1}N$	0.47	0.199
	4	$Ti_{0.8}Al_{0.1}Nd_{0.1}$ 400nm	$Ti_{0.8}Al_{0.1}Nd_{0.1}N$ $Ti_{0.5}Al_{0.4}Nd_{0.1}N$ の交互15層	0.39 0.49	0.231
	5	Ti 50nm	$Ti_{0.4}Al_{0.4}Nb_{0.2}N$	0.55	0.222
比較例	6	Free	$Ti_{0.5}Al_{0.5}N$	7.87	2733穴折損
	7	Free	$Ti_{0.5}Al_{0.5}N$	5.99	0.456
	8	TiN 1.0u	$Ti_{0.5}Al_{0.5}N$	8.57	0.501

【００１８】表３より明らかなように、ドリルのように連続的な切削を含む工具では、金属層又は合金金属層を介在させて良く密着し、耐摩耗性を有すると共に耐酸化性に優れる元素を添加したものがより有効であった。

【００１９】次に、切削では耐酸化性が相乗効果的にしか表せないため、各種第三成分の添加効果を、第三成分※

※を含む皮膜を先の実施例同様にコーティングし、９００℃、大気中で１時間酸化させた。その時に形成した酸化層の厚さを断面観察にて測定した。その結果を表４に示す。

【００２０】

【表４】

	皮　膜	酸化層厚さ（ﾐｸﾛﾝ）
本発明例	$Ti_{0.5}Al_{0.4}Si_{0.1}N$	1.2
	$Ti_{0.3}Al_{0.4}Si_{0.3}N$	0.7
	$Ti_{0.5}Al_{0.4}Zr_{0.1}N$	1.5
	$Ti_{0.3}Al_{0.4}Zr_{0.3}N$	1.0
	$Ti_{0.5}Al_{0.4}Hf_{0.1}N$	1.3
	$Ti_{0.5}Al_{0.4}Y_{0.1}N$	0.9
	$Ti_{0.3}Al_{0.4}Y_{0.3}N$	0.6
	$Ti_{0.5}Al_{0.45}Nb_{0.05}N$	1.5
	$Ti_{0.5}Al_{0.4}Nb_{0.1}N$	1.0
	$Ti_{0.3}Al_{0.4}Nd_{0.3}N$	0.7
比較例	$Ti_{0.5}Al_{0.5}N$	3.2
	$Ti_{0.4}Al_{0.6}N$	2.7
	TiN	5
	TiCN	5

【００２１】耐酸化性は、その目安として表面から酸化される厚さで現した。酸化が膜の内部まで進行すると酸化により体積膨張が生じ膜は剥がれるか、切削により持ち去られてしまう。そのため酸化を表面近傍のみに食い止められれば表面は酸化物となるが内部は緻密な膜が維持されているため、工具としては十分な機能を有するものとなる。特に、Ｙ、Ｓｉ、Ｎｂでその効果が顕著であった。

【００２２】

【発明の効果】上記説明したように、皮膜の密着性を基体－皮膜間に金属又は合金金属層を設け、皮膜に残留する応力を低減することにより、フライス切削、エンドミル、ドリル等で作用する食い付き時の衝撃にも十分な密着性を保つことができ、皮膜本来の耐摩耗性を発揮することができ、また、その皮膜は配向性をＩ（２００）／Ｉ（１１１）比を２以下に制御し、それに第三成分を添加することにより、衝撃に耐え、こすり摩耗に優れた耐摩耗性を発揮するとともに耐酸化性に優れた皮膜とすることができた。

フロントページの続き

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